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The invention relates to a method for enriching a first gaseous or liquid medium with a second gas desert a liquid in a reactor, whereby the first gaseous or liquid medium flows along a flow axle of the reactor or flows or is in the batch process presented. Beyond that the invention covers reactors to the carrying out the process, like also the application of the reactors for the separation from gases and liquids.

From the US-PS 4,959,152 a separation of gases or liquids is known, with which a gas component of a first gaseous or liquid medium because of the microporous structure of the fiber walls of the capillary hollow fibers due to gradients, by capillary hollow fibers, for example in the concentration and in the pressure, which occurs capillary hollow fibers and can from these be led out. After the teaching given in the state of the art this technology can only to the separation of liquids and/or. Gases used become.

The loaded of a gaseous or a liquid medium with a second gas, thus that brought together various fabrics with the object of a material combination, represents one of the most important method steps within the chemical-biotechnological and their cognate industries. Various fabrics become for example conducted, around a reaction between various starting materials to obtained, brought a such together so that a product with high order becomes generated. Pure physical absorption processes can act, in order to solve for example a liquid with a certain gas component to loaded or however the gas flow an adherent solid in a liquid with such processes around (gas laundry).

The exchange of material generally a reactor becomes used, the corresponding desired reaction speeds, the physical solubilities, the material properties, which becomes required pressures and required temperatures designed. The center of gravity of the design and dimensioning lies to arrange the contact as wide as possible between the involved components within the reactor. In order to reach this, one generally the subsequent paths goes:

1) One of the present phases, for example the gas phase with gas/liquid reactions, becomes as fine-disperse ones as possible by many nozzles into the reactor introduced filled with

liquid.

- 2) The liquid becomes against-guided as very much thin film or drops of a gas component.
- 3) Eine der Phasen wird mit Hilfe von Einstoff- oder Mehrstoffdüsen mit sehr hoher Geschwindigkeit in den Reaktor eingetragene Aufgrund eines selbständigen oder gezielt beeinflussten Strahlerfalls wird diese Phase fein dispergiert.

The execution of the methods usually a tubular reactor becomes used, by which the gaseous or liquid medium which can be loaded flows through. The second gas and/or. the second liquid, which and/or. which is to become combined with the gaseous or liquid medium, can in the direct current or in the counterflow into the tubular reactor guided will, in order to obtain a higher concentration difference between the various phases.

Eine weitere Möglichkeit zur Verbesserung der Mischung besteht darin, das gasförmige oder flüssige Medium mit dem zweiten Gas oder der zweiten Flüssigkeit in einem Rührkessel zusammenzuführen, in dem eine hohe Turbulenz erzeugt wird, um die Phasengrenze ständig zu erneuern und somit den Stoffaustausch zu intensivieren.

Adverse one with these methods is the usually required high energy expenditure for material combination. In addition such agitating boilers contain mechanical movable installations, which require an high investment and maintenance costs.

The avoidance of these disadvantages very frequent bubble columns in the most diverse embodiments become used with gas/liquid reactions in the applied technology. A general container with Flüssigkeit is flowed through. This liquid the gas phase becomes usually supplied over rigid or elastic nozzle systems. This means that as aeration-flat essentially only the container cross section at the reactor soil is available. In order to achieve a large phase boundary surface and an effective mixing, decomposed therefore the gas flow in as fine a gas bubbles as possible becomes by corresponding nozzle systems, whereby an high Ante of the gas phase with maximum exchange of material-flat becomes achieved within the reactor. As aeration bodies become for example perforated plates, porous ceramics or perforated elastomers in the most diverse embodiments used.

Adverse one with these gas supply systems is that her only in continuous operated reactors used to become to be able, since turning the gas flow off could have an occurring of the liquid the aeration body to the sequence.

An other disadvantage with reactors to the state of the art results due to the fact that the blister-large at first produced by the aeration body within the reactor strong Blasenkoaleszenzen is subjected, whereby a equilibrium-blister-large adjusts itself, so that the efficiency cannot be improved by a reduction of the pores of an aeration body arbitrary. A higher conversion can be made here only by corresponding reactor dimensioning, for example via choice of a larger base.

Object of the invention is it now to create a method and an apparatus for enriching a first gaseous or liquid medium in a second gas or a second liquid with which a substantial larger surface is available for the exchange of material, when it is possible with systems to the state of the art, for example with aeration bodies.

The object directed on the method that initially mentioned type becomes dissolved by the fact that the second gas or the liquid becomes by essentially vertical capillary hollow fibers exhibiting to the flow axle disposed and walls with a microporous structure by the first gaseous or liquid medium guided, whereby the second gas or the second Flüssigke can occur due to gradients physical or chemical parameters, in particular pressure, temperature and/or concentration differences, because of the microporous structure of the fiber walls the first gaseous or liquid medium.

The invention is however not on capillary hollow fibers limited, instead of capillary hollow fibers can also tubes and/or elastic hoses of small diameter taken become, which are by machine perforated and which take over function of the capillary hollow fibers. Such tubes or hoses are the capillary hollow fibers equivalent. If they are more other down in the description and/or in the claims mentioned, tubes or elastic hoses of the before-described type are always along-meant.

The capillary hollow fibers with the second gas or the second liquid applied and this or this become according to invention step over the surface of the fiber walls by the pores of the fiber walls with the first gaseous or liquid medium in contact. The capillary hollow fibers become essentially vertical the flow direction disposed, so that molecules of the first gaseous or liquid medium of the capillary hollow fibers in their movement become inhibited. By the corresponding prolonged residence time of the first gaseous or liquid medium at the capillary hollow fibers the interaction is intensified. Turbulence-similar fluid movements at the fiber due to the flowing against first gaseous or liquid medium, which, develop for width mixes the bubbles or Tro of the second gas or the second liquid effective with first gaseous or liquid medium (Bubble POINTs of the used capillary hollow fibers exceed). A vertical capillary hollow fiber located for flow direction can become in principle at both ends with a second gas or a second liquid applied can, since a preferred incident-flow direction for the second gas or the second liquid is not given.

Depending upon pressure on the fiber wall of the capillary hollow fiber the second gas or the second liquid or the desired gas component or liquid component occurs gas-selective hollow fibers with use nonporously or in form very small gas bubbles that the fiber surrounding gaseous or liquid medium. Already with low pressure bubbles at the surface of the capillary hollow fibers will form, which can be cut by the flowing against first gaseous or liquid medium, whereby a particularly good mixture results. A part of the energy to the transfer of the second gas or the second liquid in the first gaseous or liquid medium becomes thus the momentum removed. With this type of the mixture it is to be expected therefore from

energetic considerations that the gradients required for occurring the second gas or the second liquid in the first gaseous or liquid medium are smaller substantial, than it is in the reverse case, like with the US-PS 4,959,152, to the separation of fabrics necessary, because here substantial other mechanism comes to the application. That differentiates the unification according to invention from fabrics of that the outer state of the art known Stofftrennung in principle.

Useful capillary hollow fibers are known from the state of the art. For example the US-PS describes 4,970,034 the production of isotropic microporous polysulfones with the help of a wet spin technology. A fusion spin technology to the production from capillary hollow fibers is for example in the US-PS 4,956,237 described. Instead of the capillary hollow fibers mentioned can also, how mentioned already above, tubes and elastic hoses used become, which exhibit a small diameter and by machine perforated are.

The invention process is above all favourable because the phase boundaries between second gas and/or. the two liquid and the first gaseous or liquid medium not by the properties, like z. B. the surface tension conditional are, but by the embodiment of the capillary hollow fibers. From that usually a very favourable volume/surface relationship, which is not more attainable by a method to the state of the art, results to small diameters of capillary hollow fibers. Thus the interaction between the second gas or the second liquid with the first gaseous or liquid medium intensified and large amounts of the second liquid or the second gas light in the first gaseous or liquid medium mixed to become.

An other advantage is that, given by the fact, like described above, a part of the energy can become the transfer of the second liquid or the second gas, from the momentum of the first gaseous or liquid medium removed, so that necessary to the transfer only small pressure, temperature and/or concentration differences are.

In accordance with a favourable development of the method become the second gas or the second liquid in various directions and planes and along the flow axle of the reactor by first gasför or liquid medium passed.

The various directions relate itself both on various directions vertical to the flow axle, and whereupon that/the second gas or second liquid of a plane in another plane other capillary hollow fibers supplied, outgoing from the capillary hollow fibers, will, in order to make the same second gas or the second liquid possible an other interaction with the gaseous or liquid medium.

The conduit second gas or the second liquid in various directions of the vertical to the flow axle has the advantage opposite a guide of the gas in only a direction that all direction components of the turbulence-similar fluid movement generated by flowing against the first gaseous or liquid medium become utilized, in order to change-work with an other capillary

hollow fiber. That leads to an intensification of the mixture.

If the second gas or the second liquid, that and/or. from a capillary hollow fiber, again by one other capillary hollow fiber leaks out into the reactor recycled, the probability of reciprocal effect for the second gas or the second liquid with the first gaseous or liquid medium is likewise improved. In addition, it becomes the portion second of the gas or the second liquid, which leaves the reactor again, reduced. The latter has the advantage before all things that the effort the return of the portion of the second gas or the second liquid, which or which with the gaseous or liquid medium mixed is, becomes smaller. This is from particular advantage, if the second gas or the second liquid toxic is and must special protection devices be met.

With other preferred developments the second gas or the second liquid becomes desert opposite the first gaseous liquid medium in the direct current or counterflow by the reactor guided.

Becomes the second gas or the second liquid, which and/or. which stands in a first plane vertical to the flow axle with the gaseous or liquid medium in compound, after exit from this plane of a subsequent plane again supplied. With a such embodiment the second gas or the second liquid relative to the first gaseous or liquid medium flows in the counterflow or in the direct current. The direct current enterprise has the advantage that pressure gradients between the first gaseous or liquid medium and the second gas or the second liquid change for few over the whole reactor-prolonged, while the counter current against the current the concentration gradients remain opposite the reactor-prolonged essentially same. Depending upon the mixture determining parameters can be met in accordance with this embodiment the optimum choice.

With another preferred process the second gas or the second liquid in the capillary hollow fibers with infinitesimal flow rate lines up. This type of the method is particularly then favourable, - if of the second gas or the second liquid only little in the first gaseous or liquid medium received will is. Then one can let there second gas or the second liquid in bottom pressure into the capillary hollow fibers. A current does not become then used, which before all things the effort for an uniform inlet and the disposal of effluent gas reduced.

In accordance with another preferredwise development of the above methods the pressure of the second gas or the second liquid becomes below blister developing pressure the held.

This is possible because, thereby, like other described above, only a part of the energy must become the mixture from the second gas or the second liquid removed, since the method can become so guided that the second gas or the second liquid can become secured out-sucked by the first gaseous or liquid medium or.

The object further directed on the apparatus to the carrying out the process becomes dissolved by the fact that summarized with a reactor with an in and outlets for the first gaseous or liquid medium and the second gas or the second liquid exhibiting housings the capillary hollow fibers are in Membranelementen.

One could arrange the single capillary hollow fibers direct in the reactor, however this adverse, there the capillary hollow fibers with change of the process, would be purification or maintenance in the reactor poor remote to become to be able. The arrangement of capillary hollow fibers in Membranelementen possible it to take as well as use for another application different again these single out of the reactor.

In favourable development of the reactor the Membranelemente exhibit at least a plane formed of capillary hollow fibers, whereby the capillary hollow fibers approximate parallel to each other run and the Membranelement vertical to this plane is flow throughable.

Due to this embodiment the Membranelemente in the flow direction of the first gaseous or liquid medium lie one behind the other. That a possible light equipment of the reactor. In particular thereby possible becomes also in advantageous manner that different Membranelemente in various planes become disposed, whereby also the mixture ability can become different applications optimized.

In accordance with other favourable development the Membranelement exhibits several successively planes disposed formed from capillary hollow fibers and.

The introduction several planes within a Membranelements increased the other size of the surface for an interaction of the second gas or the second liquid with the first gaseous or liquid medium, by the capillary hollow fibers substantial dense disposed to become to be able, when it would be possible by rear each other layering of several Membranelemente. Too if few fibers are disposed, for example in a Membranelement, as only a plane is present, the efficiency for the loaded of the first gaseous sinks or liquid medium with the second gas or the second liquid, against it many planes disposed are, develop turbulence-like fluid movements, which oppose a Widersta to flowing on the first gaseous or liquid medium. Investigations have shown the fact that Membranelemente in several planes disposed capillary hollow fibers for egg to also unite the second gas or the second liquid with the first Mediums particularly effective is, if to five planes per flow direction of the second gas or the second Flüssig within a Membranelements provided are.

In accordance with a preferredwise development of the invention the respective planes in the Membranelement become to each other rotated disposed. Due to this measure all direction components of the turbulence-similar fluid movement generated by flowing against the gaseous or liquid medium at a plane can become utilized.

Thus a particularly good mixture of the replaced bubbles with the gaseous or liquid medium, generated by a capillary hollow fiber the flowing against molecules of the gaseous or liquid medium, develops. In order to be able to use if possible all directions of the turbulences, then almost all directions in various planes should become considered.

Opposite such an embodiment with many different directions a preferred development of the invention plans to each other in each case to arrange various planes in the Membranelement around 90 DEG rotated.

With a such arrangement practical all directions become already detected, since the current represents determining physical parameter at each space point in the reactor a vector, which can be divided in two resultant components in the planes with capillary hollow fibers.

A particularly favourable development plans that in the Membranelement the capillary hollow fibers verwoben plane with the disposed capillary hollow fibers of the adjacent planes vertical in addition after type of chain and weft are.

This is particularly favourable to increase over the stability and to keep the load of the single Membranelemente small with Membranelementen with capillary hollow fibers can a problem occur, because the single capillary hollow fibers in a plane, for example due to thermal expansion, no longer defined because of a location to be or even by the current of the first gaseous or liquid medium in movement and/or. Vibration offset becomes this represents first of all a mechanical load of the capillary hollow fiber, secondly takes up the movement or vibration also Ener. Both are adverse prerequisites for the operation of a reactor. Therefore it is convenient to fasten the capillary hollow fibers. To the solution of a similar problem z sees. B. the US-PS of 4,959,152 adhesives or separate nylon threads forwards. In accordance with the development of the Erfin however vertical disposed capillary hollow fibers in form of a fabric become, like it from the woven technology with chain and weft known to each other are, with one another connected the improvement of the fixture. A such fixture is substantial more favourable, than those to the state of the art known, since it holds also with high temperatures and one does also without additional fabrics in adhesives or auxiliary threads in the ranges of the gaseous or liquid medium, which can be both for the flow guidance and adverse for the purity of the starting materials.

In accordance with a preferred development of the invention the capillary hollow fibers of a plane are against each other offset opposite the capillary hollow fibers of another plane longitudinal in same direction.

That has the advantage that all parts of the flowing through first gaseous or liquid medium with capillary hollow fibers can come into interaction. In addition, a such result could become partial by the fact achieved that the capillary hollow fibers of a plane become sufficient close together placed, whereby however for the first gaseous or liquid medium a

larger resistance develops, as if in each plane gaps between the capillary hollow fibers are left, which become closed by an offset arrangement in another plane. A such resistance would be adverse, because it leads first of all to an energy loss and secondly also to a higher pressure drop across the reactor-prolonged, which is again adverse for uniform merging over the length of the reactor. This disadvantage becomes planar eliminated by the offset arrangement in various planes.

In accordance with a special development of the invention the Membranelement is as polygonal or round frames and in particular as rectangular frames formed, between whose opposite sides the capillary hollow fibers extend in each case.

In particular with an embodiment with rectangular frames it is favourable that such Membranelemente can be manufactured due to the rectangular shape with little blend. An other advantage consists of the fact that vertical can extend to the capillary hollow fibers of a plane also different capillary hollow fibers extending in a direction for example in another plane. The advantages of such an arrangement became managing already described. The frame in accordance with the development a permitted very simple formation of such Membranelemente.

In accordance with a preferredwise development of the invention the Membranelement is as square frames formed, whereby the capillary hollow fibers seized in the frame are same in each case prolonged.

The equal length of the capillary hollow fibers is convenient, around as uniform a flowing of the second liquid as possible z reaches. Commodity a capillary hollow fiber substantial more prolonged as another, then would become by the different pressure drops due to the length a flowmoderate balance by the fact achieved that the second gas or the second liquid flows essentially only by the shorter capillary hollow fibers and the longer do not become or only few with the second gas or the second liquid applied. Unequal lengths would oppose an uniform loading of the gaseous or liquid medium with the second gas or the second liquid.

In accordance with a preferred development the capillary hollow fibers flow to the invention in each case at the respective sides of the frame in separate inlets and/or. Discharge for the second gas or the second liquid.

This has the advantage that one can lead the second gases or liquids into that vertical being stacked flow directions separate, which an additional parameter for the process optimization create the development of permitted different pressure drops in both vertical being stacked directions, which z . B. convenient to be can, in order to adjust tolerances in various lengths of capillary hollow fibers. Important is however to add that it also application possibility offers, first gaseous or liquid medium additional to second gas or second liquid also third gas or third liquid also of second gas or second liquid various transfer parameters, since due to

the development of different, from each other separated flow paths for the gas or the liquid, with which the first gaseous or liquid medium is to become loaded, for order to stand.

In accordance with a preferred development of the reactor several Membranelemente become a membrane module structural summarized.

This has advantages for a simple assembly of a reactor before all things, by several Membranelemente together into the reactor introduced to become to be able. This measure reduced not only the assembly time, if the reactor for a new, other process with other Membranelementen is to become equipped, but reduced also the time with the purification and/or with other maintenance steps.

After an other preferred development of the invention several Membranelemente in a membrane module become connected so with one another that the outlet of capillary hollow fibers of a Membranelementes in each case with the inlet of capillary hollow fibers of a subsequent Membranelementes interconnected are, so that the second gas or the second liquid in a Membranelement with opposite flow direction becomes the preceding Membranelement guided. With the help of this embodiment the described already above method can be accomplished favourably before all things.

In favourable development the membrane module essentially consists of a cage formed from four corner columns disposed between a rahmenförmigen bottom plate and a rahmenförmigen lid, into who several Membranelemente stacked are.

This structure a possible particularly light in and/or. Assembly of several Membranelemente. In addition, a such membrane module is auseinandernehmbar and with other Membranelementen expandable light

Different thick distance pieces disposed are favourable between the single Membranelementen.

The introduction of distance pieces has the advantage that the process can become optimized by variation of the distances between the Membranelementen in dependence of the size of the reactor and the desired process parameters for the mixture with standardized modules, standing for the order. The introduction of the distance pieces affected both the pressure drop over the reactor, and the mixture of the second gas or the second liquid with the gaseous or liquid medium. By choice of different distance pieces and Membranelemente other parameters are available to reach a desired mixture what is to be regarded as particularly favourable, since the reactor according to invention should be more applicable to the loading of a gaseous or a liquid medium with a second gas or a second liquid in a wide range. By various distance pieces and Membranelemente the most favorable in each case mixing ratio for various Mischproze can be adjusted.

In favourable development central additional supports are provided between the corner columns.

This measure the increased stability of the membrane modules.

One preferably development of the invention plans that the Membranelemente fit like also the distance pieces in the angular insides of the corner columns dense.

This measure permitted it to seal various sides of the Membranelemente against each other. Thus various ranges of the Membranelemente become pressure-moderate from each other decoupled. Due to this measure various flow paths with various printing can become applied, which represents an other assistance for the optimization of the mixture.

In other favourable formation at least two diametric opposite corner columns in contrast to the two other itself diametric opposite corner columns projections pointing outward exhibit themselves, which are certain to the dense fixture on the inside of the housing of the reactor.

With this formation of the invention various spatial regions of the Membranelemente become from each other decoupled by the dense fixture. The extensions have surfaces, which to the reactor wall comes to the request. Such a tightness particularly simple can be attained by the planar formation of the extensions pointing outward. The tightness will all things required, in order to separate inlet and outlet portion for the second gas or the second liquid, so that a pressure difference between inlet region and outlet portion will maintain can, which let the second gas or the second liquid flow by the capillary hollow fibers.

In accordance with a favourable development of the invention the housing of the reactor is symmetrical formed and the corner columns with their projections, cylindrical to the flow axle, attached with which they are at the inner wall of the housing, the reactor area into from each other separated spaces divided, by which the second gas or the second liquid before the penetration into the capillary hollow fibers. and/or. after leaving these capillary hollow fibers flows.

These features lead in advantageous manner to a particularly simple embodiment of a reactor according to invention. The aforementioned square Membranelemente and/or. the membrane modules can be covered by a cylindrical housing light at all corners, whereby all corners of the square frame can come in the cylindrical housing to the request. Only if an inlet region and an outlet portion separated of it are provided, only two from each other separated semi-infinite spaces required, which means, become a seal are only in a diagonal direction of the square frame required. For the seal the already aforementioned projections serve. By the dense fixture at the two corner columns the housing becomes divided into two from each other separated semi-infinite spaces, whereby some semi-infinite space becomes used as inlet and the other semi-infinite space than outlet.

In preferredwise development several such membrane modules become one above the other dense connected with one another in the interior of the reactor disposed and.

Due to the variety of such membrane modules the interaction of the second gas or the second liquid with de gaseous or liquid medium surface standing for the order other increased becomes, so that a still better gas exchange becomes possible. In principle one could summarize all Membranelemente in a single membrane module, this would have however then disadvantages, if the reactor were to become used after execution of a first process subsequent for another process, however not with that same arrangement of the Membranelemente. The assembly with several membrane modules, which are various from each other and in the interior of the reactor disposed to become one above the other to be able, an effected flexible use of such a reactor for different processes, which result in a laboratory or a manufacturing facility. This flexibility becomes achieved by the fact that several membrane modules with various Membranelementen and/or. Distance pieces to be provided and after the requirements the combinations of the various Membranelemente alone by exchange of membrane modules changed will must.

Each membrane module forms a complete portion of the reactor, such favourably that each portion a part covers D of housing of the reactor, which is provided with one covering plate on its under and top each, which passages exhibit for the execution of the second gas or the second liquid from a portion to the other one.

Due to this development of the invention it is possible to lead the current of the second liquid or the second gas by the first gaseous or liquid medium in most diverse type. Like that it is for example possible to summarize inlets and outlets or in addition, to bring the second gas or the second liquid, which withdraws from a portion, to another portion again into capillary hollow fibers to introduce, again in order it with the first gaseous or liquid medium in compound. These examples show that most diverse flow guidance possible to become to be able, whereby other possibilities become the optimization of the mixing process the order provided.

In accordance with a preferredwise development of the invention a reactor from a plurality of such portions is composite, which form a module cascade.

With the module cascade in each case the outlet for the second gas or the second liquid of a portion with the Einl for the second gas or the second liquid in another portion becomes interconnected. Thus develops only a single inlet for the second gas or the second liquid, which and/or. which becomes multiple in various portions by the only gaseous or liquid medium passed, until it out-steps at an outlet. With the help of this measure the remainder portion of the second gas or the second liquid, which from a portion out-steps, becomes reduced, because the part not received of the gaseous or liquid medium becomes multiple in

interaction with the gaseous or liquid medium brought. With this embodiment the remainder portion of the second gas or the second liquid is smaller after passes of the reactor, as if only a common inlet for all Membranelemente provided was this is therefore favourably, since only smaller compressors or pumps become required, if the not received second gas becomes or the second liquid the inlet recycled. An other advantage consists of the fact that the safety expenditure is smaller to the disposal of the second gas or the second liquid, if this and/or. these for example toxic is.

It is from particular advantage however that with the development mentioned the second gas or the second liquid does not only flow in a direction, but within the first Mediums and guided become. This measure provides for better mixing of the second gas or the second liquid with the first gaseous or liquid medium. Since with the Durchflies of a second liquid or a second gas by a capillary hollow fiber a pressure drop develops over the length the same, can with a guide in the same direction of the second gas or the second liquid by the gaseous or liquid medium an uniform mixture only incomplete achieved become, because at the inlet and at the outlet different physical conditions are present. This difference from inlet to outlet, may be also still so small it, becomes partly in accordance with the development by the fact balanced that becomes guided in another portion of the reactor the second gas or the second liquid in opposite direction.

In accordance with another preferred development of the invention in and outlet of each module become connected with one another, so that same pressure gradients in all capillary hollow fibers are present.

This possible one particularly simple construction, one must do however without the advantages and of the Herföhrens of the second gas or the liquid by the reactor, whereby taking up the second gas same-measured less or the second liquid over the length of the capillary hollow fiber results in. However if the pressure gradients over the capillary hollow fiber are small, no disadvantages of this type are to be feared and the simpler structure of the reactor conditional thereby becomes favourably apparent.

Beside the use of the reactor for enriching a gaseous or a liquid medium with a second gas or the second liquid the reactor with its developments, described above, can become also separation from gases or liquids used. This is a particular advantage opposite the state of the art, since gleic module elements for different applications used to become to be able.

The structure of a reactor is for the separation from gases and/or liquids known, become used with which also capillary hollow fibers, however is suitable this not for enriching from the US-PS 4,959,152, since the second gas can flow or the second liquid not by the capillary hollow fibers. With enriching will second gas in center capillary hollow fibers to rest, while it to inlet sides to flow will, whereby different ratios from the center became to the periphery, becomes introduced at which the second gas or the second liquid, caused, so that with a

transfer of the second gas or the second liquid in a gaseous or a liquid medium cannot become an uniform loading in all cases achieved.

In the contrast in addition with the reactor according to invention the capillary hollow fibers with the second gas or the second liquid are flowed through, so that at all portions of the capillary hollow fibers an offer in excess at flowed through second gas or second liquid is more attainable always. The reactor according to invention is thus superior to the reactor known from the state of the art with the loaded one and can become beyond that also still for the separation from gases or liquids used. The reactor according to invention possesses the advantage to be able to accomplish various operation modes like the loaded and the separation with the same Membranelementen. This a permitted standardization and affects itself inexpensive for the processing, since less various parts on bearing held to become to have.

The apparatus as well as the method of more near explanatory embodiments which can be accomplished thereby are described on the basis the Zeichnungen.

Show:

Fig. 1 to 4 perspective views various embodiments of Membranelementen, which with the invention process used to become to be able,

Fig. 5 a perspective view several Membranelemente and distance pieces of a comprising membrane module,

Fig. 6 a plan view on a membrane module formed as portion of the reactor,

Fig. 7 a section along line VII VII in Fig. 6,

Fig. 8 a schematic section by several cascade stacked on top of one another membrane modules a contained reactor, with that the second gas or the second liquid in the direct current with the first gaseous or liquid medium guided becomes and

Fig. 9 a section in accordance with Fig. 8, guided with which the second gas or the second liquid in the counterflow becomes the first gaseous or liquid medium.

In the subsequent description, as also in the figs, the first gaseous or liquid medium becomes always with fluid I and the second gas or the second liquid with fluid II referred.

For the execution of other down explained method to the loaded one of the fluid I with second fluid a II suitable reactor for the method the substantial and structural contains particularly integrates capillary hollow fibers I and/or. I min. These become vertical to the

flow direction of the fluid I disposed, within Membranelementen 2, like them in the Fig. 1 to 4 shown are. In place of the capillary hollow fibers also the mentioned already above perforated hoses can become used.

The Membranelemente 2 essentially consist of a frame with an upper frame part 3 and a lower frame part 4, between those the capillary hollow fibers 1 and/or. 1 min clamped are. Between the frame parts 3 and/or. 4 clamped open ends of the capillary hollow fibers 1 and/or. 1 min are both against each other and opposite the frame parts 3 and/or. 4 sealed. This can take place for example in the form that the ends of the capillary hollow fibers 1 and/or. 1 min in a sealing adhesive, z. B. Synthetic resin, embedded are. The upper and lower frame parts 3 and/or. 4 exhibits same in each case large flow openings 5, which the fluid can flow through into the Membranelement 2 inside and this. By this formation fluid II separated of I knows fluid by the capillary hollow fibers 1 and/or. 1 min and fluid I separated of fluid II by the Membranelement 2 flow through.

There is various framework forms to the fixture of the capillary hollow fibers 1 and/or. 1 possible, those in the Fig. 1 to 4 square shape shown permits however a simple manufacture and is particularly favourable for the incorporation into a reactor. A particular advantage results however in as much as the open ends that vertical to each other disposed capillary hollow fibers 1 and/or. 1 min of the respective planes due to the geometry on in each case a side of the frame disposed are. The inlet and discharge openings of the capillary hollow fibers 1 and that vertical capillary hollow fibers 1 min located in addition can become therefore separated from each other operated, which in particular for the flow guidance within a out several, the Membranelemente 2 comprising membrane modules formed module cascade is favourable, as late still incoming described becomes.

The square embodiment of the frame has the advantage that all used capillary hollow fibers 1 and/or. 1 min same prolonged are. Commodity this the case, different physical conditions in different directions did not become herrsc due to the pressure drop of the flowing through fluid II

Fig. 1 shows a simple embodiment of the Membranelements 2, with that the capillary hollow fibers 1 and/or. 1 min of the rectified in each case planes precise lies one above the other. In contrast to it are with in Fig. 2 represented Membranelement 2 the capillary hollow fibers 1 disposed in the respective planes and/or. the capillary hollow fibers 1 min to those into that in each case different planes against each other offset. Thus ensured that each flow two dimensional element of the fluid I similar conditions for the interaction with the capillary hollow fibers has 1 and 1 min, becomes like arbitrary other adjacent two dimensional element.

The effectiveness of the interaction between fluid I and fluid II becomes in this way increased. In principle one would know the capillary hollow fibers 1 also to the improvement

of the interaction and/or. 1 min in a plane arbitrary dense put. Such an arrangement would have however the disadvantage that the current of the fluid I a large resistance opposite becomes, whereby a part of the momentum of the fluid I is lost and/or. the pressure the same of the upper frame part 3 of the Membranelementes 2 4 strong corresponding to the lower frame part drops, which both for the maintenance uniform conditions within a complete reactor equipped with Membranelementen 2 undesirable is, as it also the Membranelemente 2 and the capillary hollow fibers 1 and/or. 1 min adverse loaded. Therefore it is more favourable, the capillary hollow fibers 1 and/or. to arrange 1 min in each case with gaps to each other in a plane, whereby these gaps by an offset arrangement of the capillary hollow fibers 1 and/or. 1 min of another plane as it were closed become. By the choice the gap-large and the degree of the displacement of the planes to each other, the size of the swirl within the Membranelementes 2, which affects direct the mixture of the fluid II with fluid the I, can become, adjusted.

With very much high temperatures the capillary hollow fibers can expand and become movable. If they become by the current D fluid I moved, they take up not only energy from the current, but become also mechanical loaded by the corresponding movements, which lowers the lifetime. Similar ratios are present, if due to other application requirements particularly elastic materials for the capillary hollow fibers used to become to have.

In order to avoid these energy-living movements, z becomes. B. in the state of the art sticking that together capillary hollow fibers or also the woven with thin fibers from nylons, polyesters or similar recommended. The capillary hollow fibers 1 and/or. 1 min know in addition, verwoben even with one another to become. A such embodiment is in Fig. to see 3, with which the capillary hollow fibers 1 with the capillary hollow fibers 1 min interlink fabric-like like chain and weft, whereby in each case one of the capillary hollow fibers 1 works 1 min than weft as chain and another vertical capillary hollow fiber located in addition.

The embodiment after Fig. 3 is particularly favourable also therefore, because no additional materials, like adhesives, nylons, polyesters or similar used and by fluid the I are flowed against. Not to fear it is thus that with works with aggressive fabrics for fluid I or fluid II parts additional materials removed become, whereby itself a change of the Membranelemente would have 2 like also an interference of the other process, with which the fluid becomes I required, by contaminants of the same to the sequence.

Fig. 4 finally still another fourth embodiment for a Membranelement 2 in which only planes rectified capillary hollow fibers 1 disposed are, shows thus to planes with vertical capillary hollow fibers 1 min located in addition was done without. Such an embodiment is to be used if because of special structural design of the reactor only in each case an inlet and/or. Outlet side 6 and/or. 7, used to become to be able.

With a such embodiment however whole is to be particularly made certain that the 1 covered if possible uniform of fluid I is the applied cross section with capillary hollow fibers, since otherwise only small swirls in axial direction of the capillary hollow fibers become 1 generated. From this reason are here also, like already in compound with Fig. 2 described, the capillary hollow fibers 1 of a plane opposite the capillary hollow fibers 1 of another plane offset.

With all in Fig. 1 to Fig. 4 described embodiments it is to be recognized that for each flow direction several planes of capillary hollow fibers 1 and/or. 1 min present are. Investigations have shown that the described membrane modules 2 most effectively with 1 to 5 planes of capillary hollow fibers 1 and/or. 1 min for each flow direction operated become.

All before-described embodiments of the membrane modules 2 can be used for the invention process. With this the fluid becomes II, with which the fluid becomes I loaded, into the capillary hollow fibers 1 and/or. 1 min guided, which possess fiber walls with a microporous structure, by which the fluid II into the fluid I penetrate can. The transfer of the fluid II from the capillary hollow fibers 1 and/or. 1 min into the fluid I happens due to gradients and physical or chemical parameters, from which in particular pressure, temperature or concentration differences are to be called. In case of of pressure gradients already a small pressure difference hands the fluid II to that between fluid II and fluid I, i.e. a pressure differential, by the pores of the microporous fiber wall of the capillary hollow fibers 1 and/or. 1 min at its outer wall brings where it a phase boundary to fluid the I and/or. Bubble forms. Due to the current of the fluid I the bubbles are cut either or due to the dynamic pressure of the current direct into the fluid I sucked. By the impact of fluid I a capillary hollow fiber 1 and/or. 1 min resultant swirls or turbulences ensures for the fact that itself fluid I with fluid II mixed good over a larger space. The supply of the fluid II into the fluid I over capillary hollow fibers 1 and/or. 1 min instead of by aeration bodies to the state of the art is above all favourable because that is appropriate for surfaces/volume ratio with capillary hollow fibers substantial more favourable as it by aeration body achieved become could. This applies above all if fluid II is a gas, because gas bubbles cannot become due to the surface tension arbitrary small held.

With the examples after Fig. 1 to Fig. 3 is the capillary hollow fibers 1 vertical to the capillary hollow fibers 1 min in various planes provided. Thus all direction components of the turbulences of the fluid become I with the impact the capillary hollow fibers 1 and/or. 1 min for washing around the surfaces of the capillary hollow fibers 1 and/or. 1 min utilized, whereby the effectiveness of the mixture fluid of the II with fluid the I increased becomes.

If larger exchange flat become between fluid II and fluid I than the 5 times 2 layers of capillary hollow fibers required, specified above, the single Membranelemente can become 2 membrane modules 8 summarized. A such membrane module 8 is in Fig. 5 shown.

In the membrane module 8 the fluid I flows by several one behind the other disposed Membranelemente 2, those by distance pieces 9 and/or. 10 in a distance from each other held become. The entire structure is held together by a cage 11, that essentially a rahmenförmige bottom plate 12, a likewise rahmenförmigen lid 16 and between both disposed corner columns 13 and/or. 14 covers. To the increase of the stability of the cage 11 can between the corner columns 13 and/or. 14 still other supports 15 provided its, like it in the embodiment after Fig. 5 shown is.

The corner columns 13 are in contrast to the corner columns 14 17 designed with projections, equally the corner columns 13 associated in each case ranges such projections 18 exhibit the rahmenförmige bottom plate 12 and the rahmenförmige lid in their, which with their outer surfaces 19 at the inner wall of a reactor housing attached to become to be able. The outer surfaces 19 rest against the inner wall sealing, how late still described becomes. Also between the corners of the Membranelemente 2 as well as the distance pieces 9 and/or. 10 and the insides of the corner columns 13 and 14 is seals provided.

After removal of the lid 11 alternate distance pieces 9 can do 16 of the cage 11 and/or for the equipment of the cage. 10 and Membranelemente 2 inserted becomes. By the choice of distance pieces different dimensions like also the order of such distance pieces 9 and/or. 10 on the one hand and Membranelemente 2 different properties on the other hand, a membrane module 8 for different applications optimized can become.

8 made already brought that together in same way, as it in connection with the Membranelementen 2 after the Fig from liquids or gases by means of such a membrane module. 1 to 4 described became. The flow directions for fluid I and fluid II are also in Fig. 5 with arrows indicated. The fluid II is led out with this embodiment by two sides of the cage 11 into the capillary hollow fibers inside and on the opposite side, while the fluid I flows by the rahmenförmigen lid 16 between the capillary hollow fibers through to the bottom plate 12.

Fig. the plan view shows 6 to a membrane module 8 used in an housing 20. The housing 20 encloses the membrane module 8, whereby the outer surfaces 19 of the projections 17 at the corner columns 13, to which lid 16 and the bottom plate 12 dense rest against the inner wall of the housing 20. The two spaces 21 formed thereby and/or. 22 serves II for the flow guidance of the fluid, with which the fluid is to become I applied. Fluid II becomes through in an housing cover 23 intended inlets 24 and/or. 25 into the space 21 introduced and bottom pressure held. Thus it withdraws into the capillary hollow fibers in the membrane module 8 disposed of the Membranelemente 2 and on the opposite side into the space 22, from which it through in the housing bottom 26 of intended outlets 27 and/or. 28 and from there into a circuit recycled, disposed or however into an other housing with another membrane module, disposed under it, guided flows will can, how late still described becomes.

The better illustration of the before-described flow guidance of the fluid II by the housing 20 becomes on Fig. 7 referred, which a section along line VII VII in Fig. 6 shows.

In on the basis the Fig. 5 to 7 described example is the flow paths of fluid II by the capillary hollow fibers 1 and that vertical capillary hollow fibers 1 min rectified, D located in addition. h., of space 21 to space 22, because only the corner columns 13 of the membrane module 8 are 20 sealed opposite the inner wall of the housing. If one would seal however all four corners of the membrane module 8 opposite the housing 20, result four spaces in the housing of 20 and two from each other separated flow paths, which could become for the fluid II used.

The arrangement of two flow paths opens the possibility to supply fluid I an other gas or fluid which exhibits for example of fluid II various pressure, in order optimum into the fluid to the I introduced to become.

The membrane modules 8 can become managing also with another than described flow guidance applied. For example the current can become so guided that the fluid II outgoing from a first Membranelement 2 becomes into the subsequent second Membranelement 2 and immediately introduced, so that the flow guidance for the fluid II in fluid the I mäanderförmig made. With such Föhrun influences of physical effects, as they can occur in the before-described example due to the different pressure existing between inlet and outlet, can become reduced.

Fig. 8 and 9 shows the arrangement of several membrane modules 8 within an housing 30 in schematic representation. This housing 30 knows z. B. integrally formed its, in which then the single membrane modules are 8 stacked disposed, in addition, it knows from several, in each case a membrane module 8 contained and as in the Fig. 6 and 7 described housings 20 composite its.

Only if the membrane modules become 8 used, 28 provided must be between these separating plates, the which similar taking off and bottom plates 23 and/or. 26 of the housings 20 formed is and passages 29 exhibits, by which the fluid II of membrane module can become 8 membrane module 8 guided. This flow path is in the Fig. 8 and 9 by means of the horizontal directed arrows for fluid II indicated.

This flow path of the fluid II is also in Fig. 9 the same, however becomes there fluid I opposite the embodiment in accordance with Fig. 8 by the reactor passed. The reactor after Fig. 8 that works after Fig in the "direct current". 9 in the "counterflow".

Due to the compounds of the single membrane modules 8 over the passages 29 in the separating plates, arranged in a module cascade, 28 the fluid II in the module cascade and guided becomes, whereby the fluid II outgoing from a membrane module 8 becomes 8

admitted into the subsequent membrane module. Of fluid I the received portion within the fluid II cannot interact thus again with fluid, so that the remainder portion of the fluid is smaller II substantial, than this would be during a flow in the same direction of all membrane modules 8 the case.

A smaller remainder portion to fluid II is in as much from advantage as its subsequent treatment becomes substantial simplified. If the remainder portion becomes again the inlet of the reactor back-pumped, whereby its pressure becomes increased, then substantial smaller compressor capacities are required. If the fluid is II toxic, then becomes smaller due to the smaller remainder portion of the effort for safety precautions and disposal.

The operation of a reactor in the direct current is favourable if for the transfer of the fluid II into the fluid I pressure differences substantial are. Due to the interaction of the fluid I with the capillary hollow fibers 1 and/or. 1 min in the membrane modules 8 is to be expected a pressure drop from the inlet side to the outlet side. The capillary hollow fibers oppose likewise fluid to the II a resistance, so that a pressure drop from their respective inlets develops also here to their discharge. With rectified current of fluid II and fluid I inlet to the outlet thus the pressure differences between both fluids become substantial less affected, than the pressures themselves, D. h., the desired uniformity with the loaded one of the fluid I with fluid the II due to pressure differences is essentially ensured by such an operation.

Differently the case lies, if the uptake of the fluid II in fluid the I is due to concentration differences in the direct current erfol. The volume fraction of fluid II in the capillary hollow fibers 1 and/or. 1 min is in the vicinity of the inlet large and the concentration of the fluid II in fluid the I low. In the vicinity of the outlet the volume fraction of the fluid II in the capillary hollow fibers is smaller against it gewor and the fluid I has a larger concentration in fluid the II believed. This means that no uniform uptake of the fluid II in fluid the I takes place, since the concentration differences vary over the reactor-prolonged. E offers itself here thus to drive the reactor in the counterflow.

In Fig. 9 represented reactor is therefore inlet and outlet for the fluid in relation to I in Fig. 8 illustrated embodiment exchanges. Analogous one to the above difference of pressure considerations is understanding that the concentration differences vary less here between fluid I and fluid II over the reactor-prolonged.

Apart from these more theoretical considerations lab tests show that the application of the countercurrent process brings considerable advantages in the aeration range, in addition, with exchange of material and separate ion processes as well as with the microfiltration. Of fluid I received amounts to fluid II was more favourable for all experiments in the countercurrent process as with an operation in the direct current.

The state of the art already shows Membranelemente with capillary hollow fibers, which are

vertical to the direction of a fluid disposed, however has this no defined output and input side. They are thus inappropriate for the loading of a first gaseous or liquid medium (fluid I) with a second gas or a second liquid (fluid II), will however in the technology used to separate gases and liquids.

A gas separation is possible against it also with the help of the reactor after the invention, this is thus more versatile more useful as the known reactors, because no different formed must become, either for the loading of a first gaseous or fluid medium with a second G or a fluid or for the separation of two liquids or gases of suitable Membranelemente used.

The invention process in compound with the apparatus a possible effective loaded one of a gaseous or fluidem of Mediums with a second gas or a second liquid in a reactor. The high efficiency is to be essentially attributed thereby to large surface areas/volume ratio for the second gas or the second liquid. The small blister-large given from the beginning by the Mikrop it becomes besides by the fact other small held that the bubbles are cut due to rushing over the first gaseous or fluid medium of the surface. A sufficient turbulence arises as a result of D particular arrangement of the capillary hollow fibers in the single Membranelementen and - modules.

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1. Method for enriching a first gaseous or liquid medium with a second gas or a liquid in a reactor, whereby the first gaseous or liquid medium flows along a flow axle of the reactor or flows or is in the batch process presented, characterised in that the second gas or fluid by essentially vertical capillary hollow fibers exhibiting to the flow axle disposed and walls with a microporous structure (1, 1 min) by the first gaseous or liquid medium guided becomes, whereby the second gas or the liquid can occur due to gradients physical or chemical parameters, in particular pressure, temperature and/or concentration differences, because of the microporous structure of the fiber walls the first gaseous or fluid medium.
2. Verfahren according to claim 1, characterised in that the second gas or the second liquid in various directions and planes to and along the flow axle of the reactor by first gasför or liquid medium passed becomes.
3. Process according to claim 2, characterised in that the second gas or the second liquid in the direct current to the first gaseous or liquid medium by the reactor guided becomes.
4. Process according to claim 2, characterised in that the second gas or the second liquid, in the counterflow to the first gaseous or liquid medium by the reactor guided becomes.
5. Process according to claim 1, characterised in that the second gas or the second liquid in the capillary hollow fibers with infinitesimal flow rate lines up.
6. Verfahren after one of the claims 1 to 5, characterised in that the pressure of the second gas or the second liquid below the blister developing pressure held becomes.
7. Reactor to the carrying out the process after the claims 1 to 6 with an in and outlets for the first gaseous or liquid medium and the second gas or the second liquid exhibiting housings (20, 30), characterised in that the capillary hollow fibers (1, 1 min) in Membranelementen (2) summarized are.
8. Reactor according to claim 7, characterised in that the Membranelement (2) at least one of

capillary hollow fibers (1, 1 min) formed plane exhibits, whereby the capillary hollow fibers (1, 1 min) approximate parallel is flow throughable to each other run and the Membranelement (2) vertical to this plane.

9. Reaktor according to claim 8, characterised in that the Membranelement (2) several successively planes disposed formed from capillary hollow fibers (1, 1 min) and exhibits.

10. Reaktor according to claim 9, characterised in that the respective planes in the Membranelement (2) rotated disposed are to each other.

11. Reaktor according to claim 10, characterised in that the planes in the Membranelement (2) around 90 DEG rotated disposed are to each other in each case.

12. Reaktor according to claim 11, characterised in that in the Membranelement (2) the capillary hollow fibers (1) plane with the disposed capillary hollow fibers vertical in addition (1 min) of the adjacent plane after type of chain and weft verwoben are.

13. Reaktor after one of the claims 10 or 11, characterised in that the capillary hollow fibers (1, 1 min) of a plane opposite the capillary hollow fibers longitudinal in same direction (1, 1 min) of another plane against each other offset are.

14. Reaktor after one of the claims 7 to 13, characterised in that the Membranelement (2) as round or polygonal frames and in particular than rectangular frame (3, 4) formed is, between its opposite sides the capillary hollow fibers (1, 1 min) extends in each case.

15. Reaktor according to claim 14, characterised in that the Membranelement (2) as square frames (3, 4) formed and thus the capillary hollow fibers calm in the frame (3, 4) (1, 1 min) same in each case prolonged are.

16. Reaktor according to claim 13 or 14, characterised in that the capillary hollow fibers (1, 1 min) in each case at the respective sides of the frame (3, 4) in separate inlets and/or.